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The processing of macadamia nuts

INTRODUCTION

The *Macadamia,* a member of the Proteaceae family, is a sub-tropical evergreen tree which produces edible nuts renowned for their quality. The nuts are claimed to be superior in flavour and texture to any other confectionery nut, and are probably the most highly priced processed nut available in the world.

Macadamia nuts are retailed almost entirely in processed form, as roasted and salted kernels. They are not easily processed, the shells being very difficult to crack, while the delicate flavour of the kernel is easily lost unless the nuts are handled with care from the time of harvesting until the final vacuum packaging of the product. Because of the problems associated with decortication, the demand for nuts in shell is small.

Production

Commercial production of macadamia nuts has become firmly established in the Hawaiian Islands and has expanded considerably during the last decade. However, although classed as a luxury commodity, production still falls far short of the market demand. Production in its native Australia has also expanded in recent years but remains only a fraction of the Hawaiian output. Successful attempts have been made to develop the crop in several tropical and subtropical areas including California and Florida, USA, Central and South America and East and Southern Africa. Because of this wide adaptability, the macadamia may well become of economic importance in various tropical as well as sub-tropical countries as a new export crop in the programme of crop diversification.

Species Suitable for Processing

Considerable confusion exists in the literature on the nomenclature of *Macadamia* spp. Ten different species are currently recognised, six native to Australia, three native to New Caledonia and one native to Celebes. However, only two, *Macadamia tetraphylla* and *Macadamia integrifolia*, are grown commercially, the remainder producing small nuts containing bitter cyanogenetic kernels which render them unpalatable and quite unsuitable for edible purposes. The Hawaiian Industry is based almost exclusively on *M. integrifolia,* varieties of which have, under their experience, proved best both as an orchard tree and as a processed nut.

When grown under favourable conditions, trees of the two commercial species may obtain a height of 60 feet or more, and a spread of 40 feet. The nuts are borne profusely, in long grape-like open clusters, each nut being enclosed in a fleshy green husk.

M. integrifolia, commonly referred to as the 'smooth-shell' species, often flowers while fruiting and hence produces nuts over a long period. The kernel is white,

fairly uniform in quality, and shrinks only slightly after harvesting. *M. tetraphylla,* the "rough-shell" species, on the other hand, produces one main crop over a short period. The kernel has a greyish colour and is more variable in quality than the *integrifolia* species. The kernels tend also to shrink more after harvesting.

Varieties

Three varieties of *M. integrifolia,* Kakea, Ikaika and Keauhou, have been planted extensively in the Hawaiian Islands. All three varieties give satisfactory production under a variety of favourable conditions. Yields from mature grafted trees can be as high as 200 lb per annum after 16 years, and may be expected to reach 300 lb per tree in double that time.

A new variety Keaau has more recently been recommended for commercial planting in Hawaii. This variety is said to be highly resistant to wind, with an overall yield 5 – 10 per cent greater than previous varieties, the entire crop of nuts maturing and dropping before the end of November.

In Australia, most of the present crop is based on *M. tetraphylla* trees, although orchards of grafted *integrifolia* varieties should soon be bearing.

Nut Quality

A number of factors need to be taken into account when assessing nut quality.

(i) Size and shape of nut: Nuts should be spherical or nearly so, otherwise problems in grading prior to cracking occur.

(ii) Shell thickness and kernel percentage: Nuts with a medium or thick shell are brittle and crack more readily using a compression type of decorticating machine. Thin shelled nuts on the other hand are less brittle, often resulting in kernels breaking during decortication. Nuts with very thin shells at the apical end are readily attacked by ants and also frequently germinate while still on the tree. The dehydrated kernel should be 33 per cent or more of the total weight of the nut.

(iii) Size and shape of kernel: Kernel size and weight are highly correlated and weight is usually the criterion used. Kernel weight should be more than 2.0g to avoid excessive labour costs in sorting and grading. On the other hand, kernels over 3.0g in weight cause problems of heat penetration during cooking, and are too large for attractive presentation.

(iv) Colour: Raw kernels should be white or light cream in colour, with little or no discolouration at the apical end. Roasted kernels should be a uniform golden brown colour.

(v) Palatability: First grade kernels should have an oil content of 72 per cent or more, while second grade kernels an oil content of not less than 67 per cent, (equivalent to a specific gravity of 1.025).

PROCESSING

Macadamia nuts are processed, on a large scale, in only two parts of the world, namely the Hawaiian Islands and New South Wales, Australia. However, Californian orchards should soon be fully bearing, and it is probable that processing will commence shortly.

Because of the difficulties encountered in producing a product with a good flavour and an acceptable shelf-life, the actual processing details have not been fully

described in the literature. The following account is based on the author's experience of the industry in the Hawaiian Islands and Australia.

The processing of the nuts can be conveniently divided into seven stages – (i) harvesting; (ii) dehusking; (iii) dehydration; (iv) cracking; (v) grading; (vi) roasting and (vii) packaging.

(i) Harvesting the Nuts

The nuts are allowed to fall from the tree when mature. It is important not to pick the nuts from the tree because of the difficulties in distinguishing between immature and mature nuts. In the majority of orchards, the nuts are still picked up by hand, although increasing attention is being paid to mechanisation of this process. With hand harvesting, costs can be reduced significantly by blowing the leaves from under the trees before the pickers go through. The leaves are blown into the inter-row leaving the nuts exposed. In some orchards, where a flat surface allows, mechanical harvesting has been introduced, a harvester originally designed for walnuts and pecan nuts having been adapted for the purpose. For mechanical harvesting to be satisfactory, it is necessary to control excessive weed-growth amongst the trees. Although ever-green, the macadamia continually drops its leaves causing further problems with mechanical harvesting. Funnels of netting to direct the falling nuts to a collection point have also been considered.

It is essential that the nuts are picked up frequently, at least once a week during the peak of the season, and even more frequently during wet weather, otherwise deterioration in the quality of final product will be evident. Damage from rats can also be serious, cases having been reported where over 50 per cent of the crop has been lost in this manner. Wild pigs eating the nuts are also a problem.

When the mature nut falls to the ground, it contains a high percentage of water, 30 per cent in the husk alone, and 25 per cent in the rest of the nut. The moisture in the husks must be removed as quickly as possible to prevent damage by moulds.

The harvested nuts should not be left in boxes to "sweat", otherwise a rapid rise in temperature will occur within the mass, resulting in deterioration. If it is absolutely necessary to hold fresh nuts for a period, it is recommended that the nuts be spread on wire mesh trays, protected from rain, no greater than three inches in depth, and raked over regularly.

(ii) Dehusking the Nuts

When the nuts arrive at the processing plant, the outer green husk is removed as quickly as possible. Various devices have been invented for this purpose, the simplest using revolving rubber wheels. A higher efficiency is said to be obtained using a revolving disc fitted with blades on its flat surface and a static labyrinth above. A rotary wire brush has also been used. Separation of the husks from the nuts is achieved by a blast of air.

Husks are used as a mulch for the soil, and some research has been carried out on utilizing the dried material as an animal feed in a mix with pineapple bran and molasses.

(iii) Dehydration

Dehydration is the most critical step in the processing of macadamia nuts, the actual conditions used by the various processors being kept strictly confidential. It is important that the in-shell moisture content be reduced to 1.5 per cent as soon as possible if flavour deterioration is to be prevented. At the same time, the kernel shrinks away from the shell making the decortication step easier.

In some parts of Hawaii, the nuts are first sun-dried but it is only possible, even under the most favourable conditions, to reduce the moisture content to about

3.5 per cent by this method; the nuts must then be artificially dried in bins to 1.5 per cent moisture before being further processed. Although sun drying to a moisture content of 3.5 per cent is not sufficiently low enough for further processing, nuts can be stored at this moisture content for long periods without flavour deterioration. However, sun-drying can cause cracking of the shells and is not to be recommended if artificial drying is available.

A typical bin drier has a square cross-section 4 ft x 4 ft and a height of 6 ft, and holds 2 tons of dehusked nuts. An initial drying temperature of 100°F is recommended, but if this temperature is exceeded initially, undesirable browning reactions occur on cooking the nuts. It has been shown that a finishing temperature of 125°F does not affect the quality of the nuts. The curing process which lasts for 2 – 3 weeks, is carried out in bin dehydrators. Tray dehydrators have also been successfully used.

(iv) **Cracking**

After dehydration, the nuts are cracked prior to cooking. Usually, it is necessary to grade the nuts into a number (up to ten) of different sizes in order that each cracking machine will receive nuts of uniform dimensions. Cracking is accomplished between stainless steel drums, the kernels being separated from the shells by a combination of sieving and air blasting. It has been found useful to centrifuge the nuts to loosen the kernels before cracking.

Experiments using impact cracking have not, so far, been particularly successful, the kernels shattering easily, and there is the additional problem of small pieces of shell being driven into the kernels.

Research at the University of Hawaii has shown that the stability of raw kernels decreases with increasing moisture content and increasing storage temperature. It was concluded that low temperature storage at 0°F was the only way to ensure kernel stability. However, storage is not normally practical commercially, the nuts being processed with a minimum of delay.

(v) **Grading the Kernels**

The kernels are sorted to remove pieces of shell and damaged kernels, and graded into first, second and inferior quality kernels. The original method of grading was based on the fact that Grade 1 kernels, having a higher oil content, and thus a lower specific gravity, will float on water, while poorer quality kernels will sink. Grade 2 kernels will float on a brine solution of specific gravity 1.025, while the poorer kernels will sink. In normal circumstances, only grade 1 and 2 kernels are considered suitable for cooking, any of poorer quality being discarded. Grade 1 kernels are processed further for retail use, while grade 2 kernels are used in the baking and confectionery trades, or sold for local consumption.

Air flotation is now used to grade the kernels eliminating the need for further drying before cracking.

(vi) **Roasting the Kernels**

At one time, it was generally considered that the main cause of off-flavour deterioration in processed macadamia kernels was due to oxidative rancidity, and the use of improved packaging techniques which excluded oxygen, greatly improved the shelf-life of the product. However, it has also been suggested that quality deterioration is partly due to lipid enzymes not being fully inactivated during the roasting procedure. To obtain maximum shelf-life, a satisfactory time/temperature roasting relationship, coupled with the latest packaging techniques, must be used.

Two methods of roasting macadamia kernels have been used, namely oven roasting, and deep frying in coconut oil, although only the latter method is currently being used commercially. It is important to note that different cooking time/temperatures

are required for kernels from *M. tetraphylla* and *M. integrifolia*. Thus it is necessary to separate the two species before processing, otherwise a very variable product will be produced. In the Hawaiian Islands, where only *M. integrifolia* are grown commercially, this problem does not arise.

In the Hawaiian Industry, the kernels (*M. integrifolia*) are practically all deep fried in refined coconut oil (containing a suitable antioxidant) at a temperature of about $275 \pm 5^{o}F$ for 12 – 15 mins. Typically, a batch of kernels is placed in stainless steel wire baskets and lowered into a stainless steel vat containing the oil thermostatically controlled at the cooking temperature. If *M. tetraphylla* kernels are being deep fried, a temperature of $260^{o}F$ for about 12 mins is recommended.

After frying, the kernels are drained, centrifuged to remove excess oil, and cooled. Nuts to be salted are then coated with coconut oil, and salted, the fat ensuring adhesion of the salt to the kernel, and providing a shiny, attractive appearance.

In the oven roasting method, the kernels are roasted for 15 to 20 minutes in a slowly rotating, perforated, stainless steel drum through which hot air at 325 to $375^{o}F$ is blown. A very acceptable product is obtained by this method, which eliminates the hazards associated with deep-frying such as peroxidant contamination and the use of rancid oil. However, the colour of the kernels roasted in this way is not generally as uniform as that produced by deep-frying.

The kernels are coated with coconut oil and salted as before.

Some kernels are roasted but unsalted, used in chocolate and toffee covered confectionery.

(vii) Packaging

The roasted, salted kernels are carefully sorted, and vacuum packed in glass jars or tins. It is essential that the processed kernels be packed as soon as possible after salting and cooling, since they will absorb moisture readily. The average storage life for first grade roasted kernels in vacuum cans at ambient temperature is up to two years for *M. integrifolia*, but considerably less for *M. tetraphylla.*

NOTE

The Tropical Products Institute is currently working on process techniques for Macadamia, and also on the market prospects.